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HARDMAN II Applied to the Forward Area Air Defense (FAAD) Line of Sight-Forward (Heavy)

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The Manned Systems Group of the U.S. Army Research Institute is responsible for the development of analytical methods in support of the Army's MANPRINT (Manpower and Personnel Integration) initiative. This report deals with the trial application of HARDMAN II, an automated derivative of Hardman (Hardware vs. Manpower) analysis to the Forward Area Air Defense (FAAD) Line of Sight-Forward (Heavy) (LOS-F(H)) system. The analyses were conducted to test the HARDMAN II methodology in a situation where data requirements were minimally met and where time constraints were severe. Another objective was to provide decision makers with timely input in the form of workload-driven maintenance manpower estimates for LOS-F(H), thus demonstrating its utility as a MANPRINT tool. Results showed that manpower requirements would be adequate only if the Built-In Test (BIT) equipment met required performance specifications. At more realistic levels of BIT performance, it was demonstrated that for each LOS-F(H) battery of 12 systems, a total of five Military Occupational Specialty (MOS) 24X systems mechanics would be required instead of the four originally called for.

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INTRODUCTION

The LOS-F(H) HARDMAN II Project

The Manned Systems Group of the U. S. Army Research Institute (ARI) is responsible for developing analytical methods in support of the Army's MANPRINT (Manpower and Personnel Integration) initiative. A part of this process is the trial application of new and revised methods to ongoing Army programs. In this way the MANPRINT tool is tested, while providing the potential user with analytical results which in turn can lend valuable input into the decision-making process.

HARDMAN II was formerly called MIST (Man Integrated Systems Technology). An automated form of HARDMAN (Hardware versus Manpower) analysis, it has been applied to the Forward Area Air Defense (FAAD) Pedestal-Mounted Stinger, or PMS (Stewart & Shvern, in preparation) for purposes of generating manpower and personnel estimates and for timely input into the acquisition decision process. The objectives of the present effort were the same though time constraints were more severe.

Background

FAAD is an integrated system comprising five components: the Line of Sight-Forward (Heavy) (LOS-F(H)), which is the subject of the present report; the Non Line of Sight (NLOS), based on the Fiber Optic Guided Missile (FOG-M); PMS, a rear area defense system mounted on the High Mobility Multipurpose Wheeled Vehicle (HMMWV); the FAAD Command, Control, and Intelligence (C^2I) system which will link electronically all the other FAAD components; and finally, the combined arms heavy division.

FAAD will be the successor to the Short Range Air Defense (SHORAD) system. A FAAD battalion will be an organic part of every combined arms heavy division. The impetus for development of FAAD was the cancellation of the Division Air Defense (DIVAD) mobile anti aircraft gun system in 1985. A new, integrated system had to be acquired and fielded rapidly. Combat developers involved in the FAAD acquisition needed timely input on the manpower requirements for the new system. This was especially true in the area of maintenance manpower, in that it was unknown

whether the SHORAD organization would support the more complex FAAD system. As a matter of policy, the total manpower for FAAD was not to exceed the SHORAD "footprint" of 626 spaces.

Thus systematic, workload-driven estimates for maintenance manpower were needed. It was the chief purpose of the present analysis to provide these on short notice, (approximately three months) for the LOS-F(H) component of FAAD. Since very few maintenance related issues were to be addressed in the testing of FAAD LOS-F(H) these estimates were deemed critical in importance.

System Description

The LOS-F(H) component of FAAD is designed to counter unmasked attack helicopters and fixed-wing attack aircraft. The weapons system will consist of a hybrid missile and 25 mm or .50 cal gun system (or a mixed 25mm-.50cal gun system, depending upon the vendor's approach). Passive electro-optical sensors will be employed along with a target acquisition radar system.

Depending on the vendor's approach, the LOS-F(H) may or may not be equipped with target tracking radar. Survivability and mobility will be commensurate with the Bradley Fighting Vehicle (BFV), or the M1 Abrams Tank. The present effort focused on the BFV principally because of time demands. Data on the BFV were more accessible in a shorter period of time.

The LOS-F(H) will be deployed in the FAAD heavy battalion, in three forward firing batteries, each comprising 12 systems. Each battery in turn will consist of three platoons of four systems each. The LOS-F(H) will have a three-man crew, consisting of a commander, gunner and driver.

LOS-F(H) will consist of off-the-shelf components. The major subsystems and components are listed below.

Missiles
Missile Launcher
Gun(s)
Weapons Interfaces
Weapons Platforms
Azimuth-Elevation Drives
Weapons Fire Controls
Sensors and Displays
IFF (Identification Friend-or-Foe) System
Range Finder Optics
Controls
Communications
Tracked Armored Vehicle
Support Equipment

Operational and Technical Testing of four candidate prototypes for the FAAD LOS-F(H) was completed by the end of October 1987. The Martin Marietta-Oerlikon Air Defense Anti-Tank System (ADATS) was selected as the LOS-F(H) on 30 November 87. Other candidates were: Liberty (LTV-Thomson CSF); Paladin (Hughes-Aerospatiale-MBB), and Tracked Rapier (British Aerospace).

Current Maintenance Manpower Allocations

The FAAD Table of Organizations and Equipment (TOE 44-167L000) divided organizational maintenance into motor and systems maintenance sections. Systems maintenance, which includes all components except the BFV carrier, required four military occupational specialty (MOS) 24X systems mechanics while motor maintenance called for 11 63T tracked vehicle mechanics for a battery of 12 LOS-F(H) systems and all other tracked vehicles in the battery. There are other MOSs at the two maintenance sections who are not directly pertinent to the present effort: these are the 63B wheeled vehicle mechanic (6) and the 24X NLOS systems mechanic (2).

The main advantage of HARDMAN II over HARDMAN is the speed with which computations can be performed. In order to produce manpower estimates, RAM (Reliability-Availability-Maintainability) data such as mean time between failures (MTBF) and mean time to repair (MTTR) for the major systems, subsystems, and components are input into HARDMAN II. Also required as input are data on the MOS who will be performing the maintenance, and the level at which the maintenance takes place.

METHOD

Data Requirements

For the present analysis data sources included Sample Data Collection (SDC), Navy Materiel Maintenance Management (3-M), Manpower Requirements Criteria (MARC) and contractors' RAM estimates for systems and subsystems similar to those found on the Pedestal Mounted Stinger (PMS) component of FAAD. Additional RAM data were based on Missile Command (MICOM) and Communication and Electronics Command (CECOM) estimates and on field test results. The present analysis necessitated much more reliance on contractors' estimates and MICOM assessments than did PMS HARDMAN II. This is because for the PMS analysis the HARDMAN II team was able to access data for the Lightweight Air Defense System (LADS) which was highly similar to PMS. The data, which served as input to the LADS HARDMAN analysis, (Dynamics Research Corporation, 1986) consisted primarily of MARC, 3-M and SDC data. These data sources were not available for most components of LOS-F(H); hence

the degree of confidence which the HARDMAN II team is willing to ascribe to the present sets of estimates is lower.

Operational Requirements

Operational requirements such as usage rates and system density were also provided as input. Data output from HARDMAN II included Maintenance Manhours (MMH) by MOS and paygrade, by component (system or subsystem), and the number of manpower spaces required for each MOS by paygrade. Personnel pipeline estimates are also produced, which show the number of MOSs required to support a battalion "slice" for the weapons system.

Baseline Comparison System

The analysis team saw an excellent opportunity to employ HARDMAN II in a situation where the normal time required to construct a consolidated data base (normally ten man months) was simply not available. Under such time press highly detailed descriptions of each vendor's system cannot be assembled; instead, a notional Baseline Comparison System (BCS) is constructed out of whatever data are obtainable within the time frame. This BCS, though not describing an individual proposed system, consists of components that may be common to all of the proposed systems, to some or even one of them, or to a very similar fielded system. In short, the BCS is a composite picture of what a tracked air defense missile system would look like and can thus be termed "generic."

If one were to attempt to compare the BCS to any of the four candidates, it would be fairly accurate to state that it comes closer in overall configuration to the ADATS and to a lesser extent, to Liberty, than to either Paladin or Tracked Rapier. This is by virtue of the fact that detailed RAM data were available for ADATS, and detailed equipment lists for Liberty, but much less so for the other two. Some components of the fire unit, such as the Forward Looking Infrared (FLIR) system, were adapted from PMS, which shared similar components. PMS, however, had no radar system, and contractor-supplied estimates for radar MTBF seemed overly optimistic in light of typical MTBFs for similar fielded radars.

Thus the HARDMAN II team was forced to adjust the MTBFs for some of these components substantially downward to agree with guidance received from subject matter experts (SMEs) who maintained them. Still, it was the overall impression of the HARDMAN II team, based on previous experience with PMS HARDMAN II and interviews with subject matter experts that in the main, the MTBF figures for the BCS erred on the optimistic side, even after the above adjustments had been made.

MTTR figures were obtained principally from EER, Inc., a firm which had contracted with Directorate of Combat Developments (DCD) at Fort Bliss to conduct Logistical Support Analyses (LSAs) on LOS-F(H). These figures were derived through a complex set of algorithms for a generic BCS which was somewhat more similar to the Liberty system than to the three others. Other MTTR data were obtained from Requests for Information supplied by contractors to MICOM.

Sensitivity Analysis

Since a central question complicating the maintenance manpower picture for FAAD is the success or failure of Built In Test (BIT) equipment to isolate electronic and other system faults, a post hoc sensitivity analysis was considered justified. This analysis was done manually, using HARDMAN II estimates as a starting point for the "ideal" situation where BIT isolation rates are assumed to be 81%, as called for in the Required Operational Capabilities (ROC) document. The analysis took the MTTR figures for BIT and manual fault isolation (FI) and repair times, and apportioned these according to the percentage of faults isolated manually or automatically. By this methodology it was determined what the total maintenance manhours (MMH) and hence manpower requirements would be at varying levels of BIT performance.

RESULTS AND DISCUSSION

Maintenance Manpower Requirements

The estimates which follow are for the total LOS-F(H) battalion of 36 systems. A total of 15 maintainer spaces is needed at organizational level, 13 at Intermediate Forward-Direct Support (IDS), and 14 at Intermediate Rear-General Support (IGS). Table 1 presents these requirements by level of maintenance. The relevant MOSs are: 24X, systems mechanic; 27X, systems repairer; 52D, power generator repairer; and 63T, Infantry Fighting Vehicle systems mechanic.

Table 1

Maintenance Manpower Requirements

Level	MOS			
	24X	27X	52D	63T
Organizational	12	_	_	3
Intermediate DS	_	8	1	4
Intermediate GS	_	8	1	5

All estimates assume productive maintenance manhours of 49 hours per week per person. Because the RAM Rationale and other FAAD documents assume 80 percent full time equivalence (FTE) at Intermediate DS and GS for the LOS-F(H) system, the estimates for this level of maintenance will exceed the FTE requirements for the LOS-F(H) "slice." For example, Intermediate DS workload driven manpower requirements called for the equivalent of six 27Xs. This would translate into the distribution of the workload over a total of eight maintainers because the 27Xs at I DS and I GS are only committed to work on the LOS-F(H) for 80 percent of their time.

Maintenance High Drivers

Table 2 below lists those five systems and subsystems considered to be high drivers because of their disproportionate demands on maintenance manpower resources. Maintainer workload is defined in terms of total maintenance man hours (MMH) per 7 days. Qualification as a high driver is defined as a workload exceeding 40 MMH per 7 days.

Estimates will be presented as simple rank- orderings of percentages of total workload attributable to a given component. Even though variation occurred in MMH over several iterations of the present analysis, the rank ordering of percent workload and percentages themselves did not show significant change.

Table 2

Maintenance Workload High Drivers

Level of Maintenance	Percent Total Workload
Organizational	
Subsystem	
Bradley Fighting Vehicle (BFV)	21
Sensor Suite (Incl. Acq. Radar)	12
Launcher	09
FLIR	06
SINCGARS	06
Power Supply	05
Intermediate Forward-Direct Support	
BFV	28
Sensor Suite	17
Intermediate Rear-General Support	
BFV	32
Sensor Suite	30
Azimuth-Elevation Drive	10

Sensitivity Analysis Results

For purposes of these analyses it was assumed that the additional manual diagnosis required because of lower BIT effectiveness would be equally distributed between the different LOS-F(H) components. The proportional increases in fault diagnosis time were also assumed to be equal for all components. This permitted the analysis to be conducted at a higher level of aggregation to yield the results in Table 3.

The results of the HARDMAN II analyses assumed that the diagnosis of electronic and other system faults via BIT equipment will be the required 81% (72% successful isolation to a single Line Replaceable Unit (LRU); the remaining 9% are considered successful if isolation is to a prioritized list of five LRUs). It is unlikely that BIT will perform as

successfully as required, at least initially (see Nauta, 1985, for a comprehensive review of the BIT technology).

Analyses were performed for several more likely levels of BIT effectiveness in order to determine the requirements for MOS 24X at the organizational level of maintenance (for a total battalion of 36 systems). Table 3 presents the manpower requirements per battery.

Table 3

Manpower Requirements for MOS 24X as a Function of BIT

BIT Effectiveness (Percent FI)	Manpower Requirement per Battery (x3)
.81	4
.65	4
.50	5
.30	5

The estimates in Table 3 are probably low because in many cases contractors' RAM estimates, which tend to be optimistic for a variety of reasons such as failure to consider the actual severity of the operational environment, had to be used. Several additional 24X slots may be required beyond those which are shown in Table 3 depending on the degree of optimism reflected by the RAM estimates.

Extrapolating from the limited data available, it would seem that at least fifteen 24Xs (five per battery) would be a more reasonable recommendation than the twelve attributable to the HARDMAN II analysis. BIT fault isolation rate will probably not exceed 50%. Similarly, the manpower estimates at the Intermediate level are "best-case" figures. They are based on the assumptions that BIT effectiveness will be on the order of .81 successful fault isolation and that the contractor RAM figures are realistic. To the extent that these assumptions are not met, (and historical precedent suggests that they will not) the intermediate maintenance level manpower requirements will be understated. The HARDMAN II analyses performed on LOS-F(H) and on PMS have used sensitivity analyses as the centerpiece for the examination of trade-offs between BIT performance and the maintenance burden of the system. This was critical to the derivation of any reasonable manpower estimates, in light of the fact that HARDMAN II assumes that the proposed level of BIT effectiveness will be the level attained. A combat developer

relying on this assumption would be doing so to his own peril. In keeping with the present findings and with the history of BIT systems, it seems wiser to err on the conservative side. Thus, if a combat developer wished to estimate a "safe" number of 24Xs a LOS-F(H) battery, it would appear that five would be a reasonable number.

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